NASA TECH BRIEF

Lewis Research Center

Rotating Turbine Blade Pyrometer

The Problem:

Jet engine performance is closely linked to the maximum operating temperature of the turbine blade material. When a blade is constructed with internal blade passages and surface perforations for the flow of cooling fluids, the surface temperature distribution can show significant changes over a distance less than one millimeter. Conventional temperature measuring instrumentation comprises thermocouples attached to the blade to obtain temperature at a moderate number of points. Thermocouple installation is complex and time consuming. In those cases where turbine blades are of a thin wall or hollow wall construction, the installation of many thermocouples may have a deleterious effect on the blades.

The Solution:

A non-contacting pyrometer system for optically measuring surface temperature distribution on a rotating turbine blade, comprising a line-by-line scan via a fiber optic probe. Figure 1 depicts the path of scan lines along the blade surface. Each scan line output is converted to digital signals, temporarily stored in a buffer memory, and then processed in a minicomputer for display as temperature.

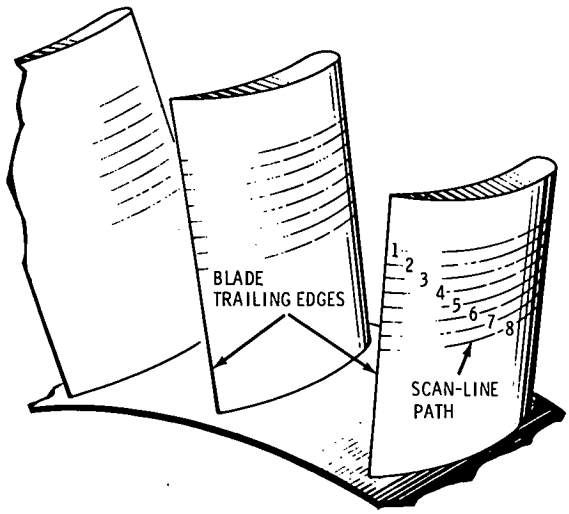

Fig. 1. - Turbine blade surface scanned by optical probe.

How It's Done:

The pyrometer, shown in Figure 2, has a fiber optic probe with a row of 80 fibers focused on the blade in a radial direction. Each fiber has an image diameter of 0.05 cm (0.02 in) at the blade. In operation, the rotating blade moves past a fixed point of focus, generating a raster of 80 scan lines.

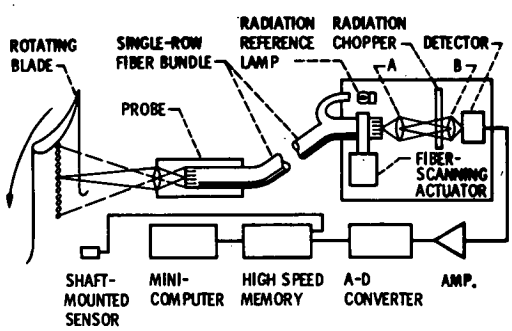

Fig 2. - Turbine blade pyrometer.

The flexible fiber bundle extends outside the engine to a box where radiation leaving each of the fibers in turn is collected by a microscope and focused on a detector. The microscope views each fiber in sequence by intermittent advance of the fiber row with an actuator. Thus the blade area is scanned line by line during a time of one to two minutes. A radiation chopper, synchronized and phased to the turbine rotation, intercepts the radiation during one-half of each revolution to provide a dark-input data sample. A shaft-mounted sensor generates a synchronizing pulse to precisely time the blade position and to select one blade for the start of measurement. Radiation from the internal reference lamp is transmitted by three fibers placed in-line with the row of 80 fibers at the fiber-scanning actuator.

(continued overleaf)

Each scan-line on the blade occupies a fraction of the turbine circumference. During this time, the detector output is digitally recorded in the high speed memory. Thus, during the greater part of each revolution, time is available for data handling.

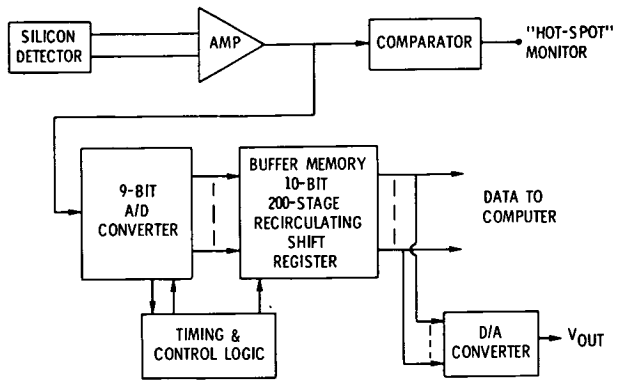

Fig 3. - Block diagram of signal conditioning electronics.

Figure 3 is a block diagram of the signal conditioning electronics. The detector output is amplified and then fed to an analog-to-digital converter. The rapid production of digital data (two megahertz rate) is in excess of allowable computer input rates, thus requiring a data buffer memory. The memory can be loaded with data and then shifted into a computer at a slower rate. These temperature data can then be displayed on an oscilloscope for study.

Notes:

1. The high speed digitizing rate results in resolution of better than 0.05 cm (0.02 in). Since blade temperatures change quickly over short distances, the small spot diameter permits many temperature readings with greater fidelty and thus improves the measurement of true maximum temperature.
2. An electrical trigger operated by the turbine shaft permits the selection of a test blade or blades for observation.
3. Further information is available in the following report:

   NASA TM-X-68113 (N72-32459), Pyrometer for Measurement of Surface Temperature Distribution on a Rotating Turbine Blade

   Copies may be obtained at cost from:

   Aerospace Research Applications Center
   Indiana University
   400 East Seventh Street
   Bloomington, Indiana 47401
   Telephone: 812-337-7833
   Reference: B74-10068
4. Specific technical questions may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B74-10068

Patent Status:

Inquiries concerning rights for the commercial use of this invention should be addressed to:

NASA Patent Counsel
Mail Stop 500-113
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

Source: D.R. Buchele and D.J. Lesco
Lewis Research Center
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